



# Hybrid Chemical-Electric Propulsion (HCEP)

## Phase I STTR

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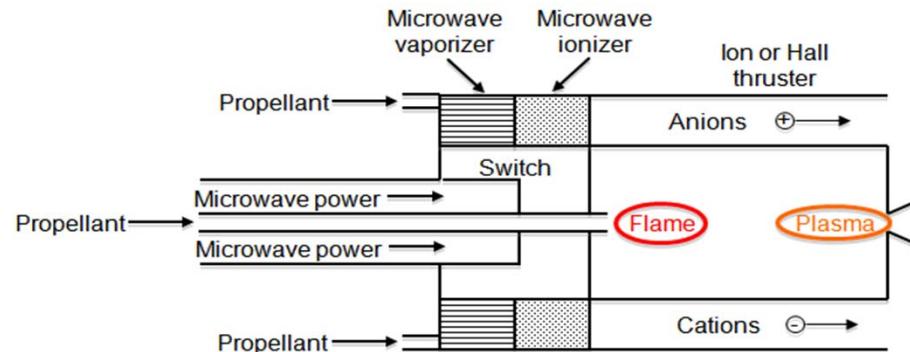
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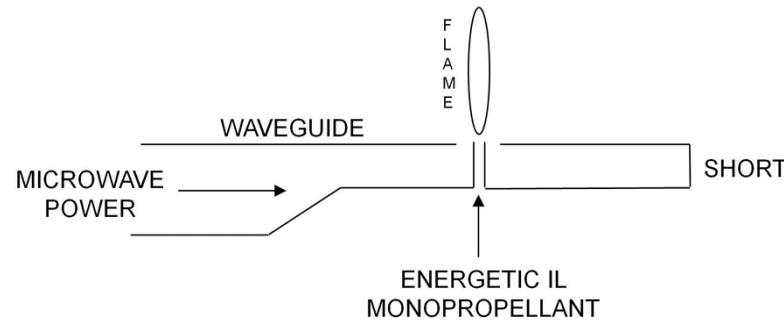
# HCEP Thruster Concept

- Can be operated as a chemical thruster and a low or high  $I_{sp}$  electric thruster using same ionic liquid (IL) propellant
  - *Chemical, high thrust mode* – Ignite and bring to complete combustion using microwaves in central chamber
  - *Low electric  $I_{sp}$  mode* – Electrothermal heating of combustion products to  $\sim$  double  $I_{sp}$  (<1000 s)
    - Estimated 3-N thrust with 25 kW, 50% thruster efficiency
  - *High electric  $I_{sp}$  mode* – microwave energy used to ionize IL propellant; ions then accelerated electrostatically
    - Estimated  $I_{sp}$  of  $\sim$ 3000 s

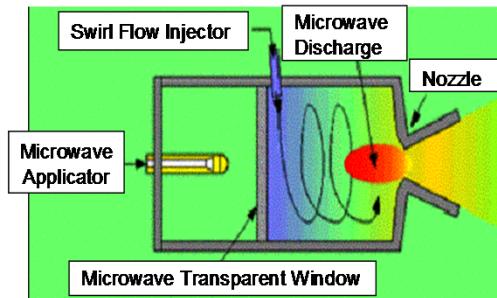


# Phase I Tasks (1 of 2)

- Characterization of IL (ionic liquid) ignition and sustainability
  - Measure microwave ignition as a function of flow rate and power
  - Testing performed at PSU facilities using available AF-315E

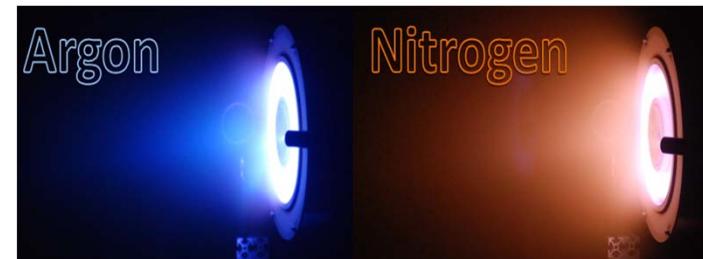


- Demonstration of microwave electrothermal heating of representative combustion products
  - Characterization of mixtures of CO<sub>2</sub>, H<sub>2</sub>O, N<sub>2</sub>, N<sub>2</sub>O, etc.



# Phase 1 Tasks (2 of 2)

- Validation of electrostatic acceleration of simulated ionic liquid components
  - Run well-characterized Hall thruster using representative IL components (CO<sub>2</sub>, N<sub>2</sub>O, H<sub>2</sub>O, and N<sub>2</sub>)
  - Compare results to Xenon performance
  - Testing performed at University of Michigan's Plasmadynamics and Electric Propulsion Laboratory (PEPL) Large Vacuum Test Facility (LVTF)



- Development of conceptual design of a HCEP thruster
  - Electrostatic acceleration design
  - Neutralizer design and integration
  - Method for switching of microwave power between igniter or ionizer
  - Thruster design to operate in 30 kW power range

